

Frequently Asked Questions Regarding Ground Vibration and Airblast From the Use of Explosives in Construction.



Virginia Department of Fire Programs
State Fire Marshal's Office

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1. WHY DOES A COMPANY HAVE TO BLAST; CAN'T THEY USE SOME TYPE OF HEAVY EQUIPMENT TO REMOVE THE ROCK WITHOUT EXPLOSIVES?

Explosives are a necessary tool in modern society. In order to mine coal, miners must remove the rock overlying the coal seam; in order to build highways, rock must be dislodged; to excavate the footing for a single-family house, rock must be removed; even the excavation of an interment site in a cemetery, may require the use of explosives to open the grave site. In many parts of the state, utilities such as water or gas pipelines require the excavation of rock which lies just below the surface of the ground.

The object of nearly all blasting operations is to break the rock sufficiently so heavy equipment can be brought in to remove the fractured rock and soil. While it is physically possible to break rock using rock saws and jackhammers, such efforts are impractical when dealing with significant amounts of rock. These methods can be very time consuming and expensive, so much so that construction and mining would be economically unfeasible.

2. WHAT ABOUT ALL THE DANGERS AND PROBLEMS ASSOCIATED WITH BLASTING?

For the employees of a company that does blasting, there are safety hazards to consider. However, these hazards are well recognized in the industry and regulated by local or state government agencies through the enforcement of the Virginia Statewide Fire Prevention Code. In addition, blasters are trained individuals who are certified by the Commonwealth of Virginia to use explosives and are knowledgeable about the safe handling of explosives. Compared to other industries and occupations, Virginia certified blasters have a very good safety record.

Another problem associated with blasting that affects the people around a blast site are vibrations transmitted through the ground. These vibrations and accompanying noise are often an annoyance to the people living and working near a blasting operation. In some very infrequent cases, they could be severe enough to break windows and crack walls. However, careful calculations and placement of the explosives can control these adverse effects of blasting. This is a responsibility of the blaster-in-charge in the manner in which they design and execute the explosive shot. The Statewide Fire Prevention Code, as enforced by local or state officials, have some restrictions on how invasive these ground vibrations and airblasts may be on people and their property.

3. WHY DOES A BLAST CAUSE THE GROUND AND NEARBY HOUSES TO SHAKE? IS IT POSSIBLE TO BLAST WITHOUT GENERATING GROUND VIBRATIONS?

As previously discussed, the purpose for blasting is to sufficiently break the rock in order for it to be excavated and removed. To accomplish this, the blaster drills a pattern of boreholes distributed evenly throughout the rock to be shattered.

These boreholes are then filled with a pre-determined amount of explosives. When these explosives are detonated, they release huge amounts of energy in the form of shock waves and high gas pressure. The energy confined in the rock shatters the surrounding rock but a small percentage of the gas pressure escapes into the atmosphere which produces the noise and air concussion. The force exerted on the rock causes the desired the fracturing effect and at the same time, produces a shock wave. It is this shock wave, or ground vibration, that radiates out from the blast site and can be felt by people or vibrates buildings.

A competent blaster will design the blast so that the maximum amount of energy released by the explosive goes into breaking and displacing the rock. The energy that escapes as noise and vibrations is wasted energy, which equates to wasted money, since it serves no useful purpose. Such wasted energy represents a higher production cost which means the blaster's goal is to also minimize this wasted energy. There is no way to design or detonate a blast that will use 100% of its energy in useful work. There will always be a small amount that will cause the undesirable effects of noise and vibration.

4. WHAT DETERMINES HOW INTENSE THE GROUND VIBRATIONS WILL BE?

There are many different factors such as geology, type of explosives, and the placement of the boreholes that can affect the intensity of the ground vibrations. However, there are two things that factor very heavily in determining what the strength of the vibrations will be. They are:

1. The amount of explosives set off at one time.
2. The distance from the actual blast site.

All the explosives in a blast are not detonated simultaneously; they are fired in sequence with small time delays separating the charges. These time delays are only a few thousandths of a second but they are critical in controlling a blast and the resulting ground vibrations. Blasters refer to the amount of explosives detonated during these time intervals as "pounds per delay".

The distance from the blast site to the location where the ground vibrations are felt or measured is important simply because vibrations will die out as they travel away from their source. The vibrations created in the ground by a blast could be compared to waves created when you drop a rock into a lake. The waves spread out in all directions and gradually decrease as the distance from the source increases. Eventually at large distances, the vibrations completely die out.

5. HOW CLOSE TO A HOUSE OR BUILDING MAY A COMPANY LEGALLY BLAST?

The fire code recognizes that it is not merely the distance from a structure that must be limited, but also the amount of explosives. Therefore, the fire code establishes a limit on the amount of explosives a blaster can use based upon the distance to the nearest structure. One option of vibration control is the use of a mathematical

formula called “scaled distance”, and is used to calculate the amount of explosives a blaster can safely use in proximity to a building. The greater the distance, the greater the “pounds per delay” that’s calculated. But that doesn’t mean the blaster will use all of the explosives allowed through this calculation because his goal is to use only that amount necessary to accomplish the job. This use of the “scaled distance” option is more conservative option for vibration control.

Some small blasting operations use only a few pounds of explosives and can be used to blast in close proximity to structures without causing damage. There are numerous cases of trench blasting within 10 feet of houses where the blaster detonated 1/2 pound of explosives without causing damage. The code allows a blaster to blast anywhere in the vicinity of houses so long as he reduces his explosive charges accordingly. But this is not to say people will not feel the resulting vibration.

In some instances, by using a seismograph a blaster may use more explosives than “scaled distance” would permit. With this option, the blaster is actually measuring the vibrations generated by blasts. When using a seismograph, the fire code also has established limits using a different scale for determining how much a building may be shaken. Regardless of which method of vibration control is used, it’s important to understand that there will be some shaking, it’s just a matter of how much shaking is permitted in order to accomplish the job while at the same time, not cause damage.

6. WHAT IS A SEISMOGRAPH?

A seismograph is a very sensitive electronic instrument designed to measure and record the intensity of ground vibrations. Some seismographs are built to measure natural earthquakes. The seismographs used in blasting operations operate on a similar principle as earthquake monitors and are manufactured specifically to measure the type of ground vibrations generated by blasting.

A seismograph placed in or near a home will detect the vibration of the ground around the house caused by blasting or any other disturbance. Some routine household activities such as slamming doors, jumping down steps, etc. can frequently show up on a seismograph recording. Even a dog or child running by the installed seismograph will cause a vibration recording.

7. WHAT DO THE SEISMOGRAPH READINGS MEAN?

Modern blasting seismographs make a trace of the vibration showing the intensity and the duration of the vibration. They record a "peak particle velocity" in terms of inches per second. This number indicates the intensity or strength of the ground vibrations and may be as small as 0.01 in/sec or as large as 10 in/sec. Such peak particle velocity does not represent distances that the ground moves, but rather the speed with which the ground vibrates. Even during the strongest blast vibrations the actual distance that the ground vibrates is only a few thousandth of an inch.

A great deal of research has been done on the effect what these ground vibrations have on houses and other structures. Many universities, government agencies, and private engineering firms have conducted extensive tests in order to determine how strong ground vibrations must be before damage can be expected to occur. The US Department of Interior's Bureau of Mines has studied this problem since 1941 and is continuing to update their findings. Nearly all states and local jurisdictions that regulate blasting rely on US Bureau of Mines data when setting limits.

To get an idea of the relative strength of vibrations, refer to Chart 1 on the next page. This chart represents typical vibration levels and the effects that may appear at those levels. It is important to remember that these are average or representative values for typical homes. Any house that is well constructed and under no other stress will withstand higher vibration levels than a house which is poorly built or under some pre-existing stress. Likewise the parts of a structure that are most susceptible to damage are those made up of the weakest materials. Under normal circumstances plaster and drywall will crack long before any cracks in concrete, cinder blocks, or brick appear. This is due to the fact that such masonry components can withstand much higher levels of vibrations than plaster and drywall can.

8. IF I CAN FEEL MY HOUSE SHAKE, ISN'T IT LIKELY THAT THESE VIBRATIONS ARE CAUSING DAMAGE TO THE STRUCTURE?

It is impossible to accurately estimate the strength of vibrations based upon a person's sensations alone. As Chart 1 shows, most people can detect vibrations at very low levels and the vibrations feel severe before they actually reach the point of causing damage to interior walls of a house. Even people who work around blasting everyday cannot accurately judge the intensity of a vibration. How a blast feels depends upon many factors not related to the vibration strength. Things such as the person's sensitivity to vibration, whether they are in a basement or upstairs, and the characteristic frequency of the blast all have some bearing on how the vibrations feel. A blast will always feel more severe when it is unexpected and startles a person. However, when the same person has been warned to expect a blast and is prepared for the vibration, it almost always feels less intense.

However, vibrations at or above 0.3 inches/sec of peak particle velocity almost always feel severe to the person experiencing them inside a home. Only with the use of a seismograph can the intensity be accurately measured and the possibility of damage evaluated. Anytime the vibrations feel excessive, or a person is concerned with the potential for vibrations damaging his home, if offered, he should allow a seismograph to be installed for measuring the ground vibration levels.

Chart 1

10.00 in/sec	Cracks in solid concrete slabs or wall may appear
4.50 in/sec	Cracks in masonry may begin to appear
3.00 in/sec	Cracking may begin in mortar joints of concrete block foundations.
2.00 in/sec	Above this level, there is a possibility of structural damage occurring.
1.00 in/sec	New cracks in drywall may appear.
0.75 in/sec	Existing cracks in drywall may extend.
0.50 in/sec	Cracks in old plaster may appear, existing cracks in plaster may extend.
0.03 in/sec	Vibrations are easily detectable by people.
0.00 in/sec	No vibrations.